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13. ABSTRACT *(Maximum 200 Words)*
A computer based decision support system for developing air pollution compliance strategies, entitled the Air Compliance Advisor (ACA), has been developed by Argonne National Laboratory (ANL) and the US Army Corps of Engineers Construction Engineering Laboratory (USACERL). The Microsoft Windows based ACA can benefit environmental personnel at US DoD and industrial facilities, as well as air pollution regulators. The ACA incorporates many useful tools for considering issues related to facility wide emissions, control technologies, and regulations.

While the ACA was designed to address the needs of the DoD in dealing with US regulations, the ACA is also applicable to US industry and regulators, as well as Canadian industry and regulators. As a means of demonstrating this point, the needs of the Ontario Ministry of Environment and Energy (MOEE) are considered in this paper and an evaluation of the potential applicability of the ACA to those needs is presented. The objectives of this paper are three-fold. The first objective is to describe the ACA and the most recent improvements to the ACA. The second is to describe the needs of the MOEE in dealing with air pollution compliance. The third is to illustrate how the ACA can be used to meet the needs of the MOEE.

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The Air Compliance Advisor and its Potential Applications with the Ontario Ministry of Environment and Energy

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1.0 INTRODUCTION

A computer based decision support system for developing air pollution compliance strategies, entitled the Air Compliance Advisor (ACA), has been developed by Argonne National Laboratory (ANL) and the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (USACERL). The Microsoft Windows based ACA can benefit environmental personnel at U.S. Department of Defense (DoD) and industrial facilities, as well as air pollution regulators. The ACA incorporates many useful tools for considering issues related to facility wide emissions, control technologies, and regulations.

The ACA is an ongoing project at ANL and USACERL, and is sponsored by the U.S. Air Force Environics Directorate of Armstrong Laboratory (AL/EQS), the Strategic Environmental Research and Development Program (SERDP), the U.S. Environmental Protection Agency (EPA), and the U.S. Army Center for Public Works (CPW).

While the ACA was designed to address the needs of the DoD in dealing with U.S. regulations, the ACA is also applicable to U.S. industry and regulators, as well as Canadian industry and regulators. As a means of demonstrating this point, the needs of the Ontario Ministry of Environment and Energy (MOEE) are considered in this paper and an evaluation of the potential applicability of the ACA to those needs is presented. The objectives of this paper are three-fold. The first objective is to describe the ACA and the most recent improvements to the ACA. The second objective is to describe the needs of the MOEE in dealing with air pollution compliance. The third, and final objective is to illustrate how the ACA can be used to meet the needs of the MOEE.

2.0 BACKGROUND/PROBLEM STATEMENT

Day-to-day activities at both industrial and DoD facilities require the operation of a wide variety of air pollution sources. Environmental Coordinators (ECs) at these facilities are tasked with maintaining compliance with applicable air pollution regulations and permits governing the operation of air pollution sources. In the U.S., the passage of Title I (Attainment and Non-attainment), Title III (Hazardous Air Pollutants), and Title V (Permits) of the 1990 Clean Air Act Amendments (CAA-90) further complicates the task of maintaining regulatory compliance. Installations are often required to modify source operations, control pollutant emissions, monitor pollutant emissions, and/or significantly increase record-keeping.

A well planned, cost-effective compliance strategy must consider many relevant issues. These issues include: source characterization; emission reduction techniques (e.g., the application of control devices, and the modification of source operations); regulatory requirements at the federal, state, and local levels, and permit conditions. Ideally the EC is knowledgeable in these areas and has the tools available to assist him/her in developing an optimized compliance strategy. A well designed computerized tool could greatly benefit ECs faced with such a daunting task. Similarly, air pollution regulators must consider each of these issues when determining the acceptability of a proposed compliance strategy. Prior to the development of the ACA, no computerized tools were available that simultaneously considered these issues.

3.0 SYSTEM SPECIFICATIONS

Three issues required clarification before developing the specifications of the software tool: (1) an understanding of who the end-user would be, (2) the specific problems that would need to be solved, and (3) the attributes of these problems.

Targeting the system to an end-user who lacked technical expertise could potentially sacrifice the power of the final tool. Targeting the most sophisticated end-user might limit the number of potential end-users. Thus, the end-user of the ACA was assumed to be an EC with a moderate understanding of air pollution sources/emissions and air pollution regulations. The end-user was also assumed to have at least a fundamental knowledge in the use of a personal computer (pc).

Upon investigating existing environmental software and base-level needs, the following software requirements were identified:

- the need to represent typical air pollution source data,
- the need to solve "standard" air pollution related problems (e.g., calculate facility-wide actual and potential emissions, size control devices and estimate their costs),
- the need for software to be extendible by the end-user to solve non-standard problems,
- the need to maximize the use of incomplete data while allowing for complete data entry for more accurate analyses,
- the need to allow the EC to play "what-if" games with the data to evaluate compliance options,
- the need to provide results for the available options in a manner the EC can understand, and
- the need to bring the EC to the point that he/she can communicate effectively with regulators, engineering consultants, and vendors.

The attributes of air pollution related problems were classified in order to select the most appropriate framework, or development tool in which to develop the ACA system (e.g., a spreadsheet format, a procedural program, a database program). Given the expected end-user, an understanding of what the ACA needs to do, and the characteristics of air pollution data and analysis, the following key attributes were identified:

- the vast amount of data
- numerous resources for obtaining data
- level of completeness of the data
- the diversity of analyses required

Each of these key attributes will be considered below.

There is a vast amount of data relevant to air pollution problems (e.g., air pollution source characterization data, operating schedules, air pollution emissions data, chemical property data, material property data, permit conditions, regulations data). Both the diversity of these data types, and the large number of instances of each data type (e.g., a facility could have hundreds of air pollution sources each operated in a multitude of ways on different operating schedules resulting in different emissions data) were considered in the design of the system and selection of the development tool.

Along with the very diverse data set relevant to air pollution problems, there are also numerous resources for obtaining the necessary data. Since the data will likely come from a variety of resources, the format (e.g., units, level of data reduction) will also vary. The ability for the end user to directly enter disparate data types would therefore be a useful system feature.

For the reasons outlined above much of the required data will be incomplete. In many cases a complete database will never be achieved, yet some level of analysis will be required. The ability to provide suggestions based on varying levels of completeness of the data was considered a requirement.

The potential types of analyses required to develop a compliance strategy are diverse and depend on the objectives of the end-user. The ability to allow different types of analyses was a further requirement that needed to be considered.

4.0 THE ACA SOLUTION

The two primary components of our solution to the above stated system requirements are: (1) the ACA software package and (2) the custom-made development tool, i.e., the EXtension Language (EXL). The ACA software package contains the data structure and analysis tools designed to simultaneously address specific issues/problems as previously outlined. Design of the ACA considered the targeted end-user while providing the power and extendibility for more advanced end-users. The EXL development tool is a tool designed in-house to address the specific attributes of air pollution related problems. The EXL helps the programmer of the ACA by allowing rapid program development with built-in error checking. It helps the end-user by allowing flexible data entry and extendibility of the source code. Both components of our solution (i.e., the ACA and the EXL) are discussed below.

4.1 The ACA System

The ACA system, illustrated in Figure 1, is a Microsoft (MS) Windows based tool. To run the ACA effectively, the users should minimally have:

- IBM PC or compatible computer
- 12 MB of RAM
- 10 MB of free hard drive space
- 486 type processor
- VGA monitor
- mouse supported by MS Windows
- MS Windows version 3.1, MS Windows 95, or MS Windows NT version 3.51 or later

The ACA is a comprehensive tool that meets the system requirements as outlined in Section 3.0. The capabilities of the ACA can be divided into 3 categories: (1) database/program structure, (2) analytical functions, and (3) interface options. Each of these areas is discussed below.

4.1.1 Database/Program Structure. The ACA serves as a database for air pollution related information. The data structure allows for air pollution related data-types including: emission sources, control devices, stacks, chemicals, and emission streams. These data-types are arranged in a hierarchical format.

Unique to the ACA is the structure for specifying operational data and regulations. Operational data is designed to allow entry of both actual and potential operating schedules and emissions. This allows the user to more accurately represent the operation of sources. The data structure for regulations allows regulatory data to be represented in three categories: (1) background and administrative information, (2) applicability data, and (3) compliance criteria.

4.1.2 Analytical Capabilities. The core of the ACA is its ability to help develop compliance strategies. In order to develop these strategies, the ACA must be able to analyze data. Some general analytical capabilities of the ACA include (1) automatic unit conversion, (2) minimal data entry requirements, and (3) user defined analyses. These capabilities are discussed in more detail in section 4.2.

Beyond the general analytical capabilities of the ACA, specific analytical capabilities of the ACA include control device costing estimates and applicability grading; calculations of potential and actual emissions; and checks for applicable federal regulations, including the National Emission Standards for Hazardous Air Pollutants (NESHAPS) and New Source Performance Standards (NSPS). Each of these capabilities is discussed in detail below.

Algorithms were developed and implemented for a variety of control technologies including: carbon adsorbers, condensers, electrostatic precipitators, baghouses, flares, thermal incinerators, wet scrubbers, and catalytic incinerators. For each control device, extensive research resulted in the development of algorithms for both the sizing and costing of the device. (1, 2, 3, 4, 5) The analysis of an applicable control device considers: air pollution source specific parameters (e.g., hours of operation, pollution stream temperature, pollution concentrations, pollution chemical characteristics, and particle size distributions); control device specific parameters (e.g., achievable reduction efficiencies, cost estimation data, operation and maintenance requirements, and applicability constraints); as well as generic economic data (e.g., cost of labor, utilities, and cost indices).

Development of the ACA was guided by the need to address issues resulting from the Title V federal operating permit program. A critical component of this program is the concept of potential to emit (PTE). PTE determines the applicability of the Title V Operating Permit program and is a key factor in writing permit applications. Once all relevant information regarding the operation and scheduling is entered, calculation of the actual and potential emissions becomes a bookkeeping problem. A unique feature of the ACA is the data structure for differentiating between actual and potential emissions through the use of operating schedules.

The ACA can be used to estimate emissions using the U.S. EPA AP-42 emission factors or factors/equations provided by the end user. Some AP-42 emission factors and equations have been encoded into the ACA (e.g., internal and external combustion sources, and fuel storage tanks).

The *Regulations Data Engine* is another component of the ACA program. The ability to incorporate the functionality of individual federal, state, and local air quality regulations will assist environmental personnel with compliance issues. The Regulations Data Engine component of the ACA program contains an encoded version of both the applicability and the functionality of a regulation. Incorporation of regulations in this manner allows the computer to search available regulations to determine which regulations do not apply to a specific source. This eliminates a majority of regulations the EC must manually investigate to determine applicability and compliance and constitutes a considerable savings of time and labor for environmental personnel. The ACA currently contains only U.S. federal regulations, including NSPS, NESHAP, and MACT standards. The ACA provides the data structure to add more regulations (e.g., state specific regulations) to the ACA, as well as the built-in capability to search for potential applicability.

4.1.3 Interfacing With Other Programs. Currently, EXL (see Section 4.2 for details of the EXL) allows the ACA to interface with external programs, both executables and databases, by a simple text file data exchange only. This method of data/analysis transfer is both awkward and labor intensive. If the need arises, EXL can be extended with features that allow the ACA to access external data sources in a more standard format.

The most important extension would give the ACA the ability to call arbitrary Dynamic Link Library (DLL) functions. With this capability, users could create their own custom DLL functions and call these functions from the ACA. For example, suppose that a user wants to read a table stored in a commercial relational database. The user would first create a DLL that reads the database, then write EXL source code to access the DLL. This would allow the ACA program to access the database. A DLL can be written using most programming languages, and can perform any arbitrary computations. If it is possible to write a C or C++ program that performs a particular action, then it would be possible to create a DLL that performs this same action.

It is important to note that DLLs are linked to the calling application at run time, and not at compile time. This means that the EXL compiler does not need to be modified in order to use a new DLL. No interaction with the EXL compiler developers is required for third parties to create new DLLs and use them from their own custom ACA libraries.

If there is sufficient need, support for accessing a particular data source can be added directly to EXL. It is possible to add primitives to EXL that allow it to query a database using Structured Query Language (SQL). SQL is an industry-standard language used to access relational databases. Most commercial databases can be queried using SQL. This would eliminate the need to create a custom DLL to handle the database access; SQL commands could be issued directly from the ACA.

Similar support for other data exchange techniques can be added to the ACA. It is possible to add the ability to use Component Object Model (COM) automation from the ACA. COM automation is a Microsoft Windows technique that allows an application to control a second unrelated application. Many commercial applications support COM automation. This allows a column of data to be either read from or written to a spreadsheet.

4.2 The EXL Custom Development Tool

Unlike most conventional programming languages, spreadsheets, relational databases, and artificial intelligence frameworks, EXL is not a proprietary language. The source code for EXL is available to the end-user. It is easy to learn to program in EXL and make changes to source code written in EXL. Programming in EXL is <u>not</u> required of the user, unless the user wants to extend the capabilities of the ACA.

Several unique features of EXL make this programming language well suited for the ACA. Physical units (e.g., "m/s") can be embedded directly into input parameters and equations written in EXL. All necessary unit conversions are performed automatically and all input parameters and equations are checked to ensure that they are dimensionally correct. Figure 2 illustrates a few different units which may be entered into the ACA.

Functions can be written that perform computations using the minimum data possible. An example of this feature is the Regulations Data Engine. The Regulations Data Engine can determine that a regulation is not applicable to a specific source even when much of the regulation and/or source's attributes are unknown. An analysis consists of concisely grouped logical statements, such as in the case of a regulation (R), a source (S), and a pollutant (X):

- if the construction date of S is earlier than the construction date specified in R, or
- if the S emission rate of pollutant X from S is less than the specified emission rate of pollutant X in R, or
- if the source classification of S is different from the source classification that R pertains to, or etc...

If any of the statements is found to be true (even if the validity of the other statements is not known) then the ACA can rule out the applicability of this regulation for source S. The code can be written so that unknown values do not cause the evaluation to terminate.

The user may select from three different levels which vary in degree of understanding. A user can set the ACA to "novice" mode. This reveals the minimum number of variables needed to perform a majority of the calculations. Alternatively, the user may select the "intermediate" mode. This mode reveals variables required for more detailed analyses. The final mode, "expert," allows the user access to all variables, equations, and relationships between variables. Advanced users can make small revisions, replace entire equations, or extend the system with entirely new pollution sources and control devices. This mode is currently under development.

A recently published paper provides a more detailed description of EXL. (6)

5.0 RECENT IMPROVEMENTS TO THE ACA

To date, two beta test versions of the ACA have been made available on the ACA Development Group's World Wide Web site (http://quattro.me.uiuc.edu/~acad). While finding beta testers for the ACA has been a challenge, some feedback was obtained on the functionality and ease of use of the ACA. Based on this feedback a number of modifications have been made recently. These modifications include:

1) the addition of a "units conversion utility"
2) the addition of "what-if" scenarios
3) a link to the U.S. EPA "CEM Cost Model Version 2.0"
4) the addition of user level options
5) an improvement in the graphical representation of the data
6) an increase in the speed of program execution
7) a reduction in the complexity of starting the ACA

The "units conversion utility," (accessible from the main menu bar), allows the end user to convert the value of a parameter from one set of units to a different, dimensionally equivalent, set of units. If an end user wanted to know the equivalence in "kg-in/day" for 12.2 "lb-ft/hr," the ACA's "units conversion utility" would be able to provide that information (i.e., 1,593.7 "kg-in/day").

Some end users expressed the interest in being able to perform some of the analyses options with a less complete data set. For example, the user would only use control device sizing, costing, and applicability analyses for a set of pollution stream parameters instead of a complete emission unit. A newly constructed "What If" data structure allows for the control device sizing, costing, and applicability analyses for a set of pollution stream parameters. Similar "What If" data structures will be constructed to take advantage of the other analyses options in the ACA.

U.S. EPA "CEM Cost Model Version 2.0" estimates the cost of air pollution monitors and analyzers. In order to allow users of the ACA to make these same types of estimates while maintaining one database, a link between the data structure of the ACA and the CEM Cost Model was created. Users can enter the relevant data in the ACA with the calculations being handled seamlessly by the CEM Cost Model. Results of the analyses will appear in the ACA. Similar links to EPA screening dispersion models are envisioned.

Since numerous, heterogeneous types of information are required for developing air compliance strategies, there are a significant number of data types and parameters in the ACA. Feedback on the first beta test version indicated that the abundance of data types and parameters made the system confusing and hard to manage. Further, a majority of the data types and parameters in the ACA are used only in special situations, while a few data types and parameters are used often. This suggestion prompted the development of the previously discussed "user levels." Section 4.2 provides greater detail on these new "user levels."

Improvements to the graphical representation of the data required the restructuring of basic data types, and a modification to some of the icon images. ACA beta test version 5.1 was extremely slow when performing analyses. This obviously frustrated beta testers. Modifications to the EXL have allowed a significant improvement to the speed of performing analyses (up to 30 times faster). Finally, previous versions required the execution of two separate programs in a specific order to start the ACA. Version 5.2 requires only one step, thus simplifying the program start-up.

6.0 CASE STUDIES

The ACA is currently at the beta test level (version 5.2) and is undergoing testing and validation of methodologies and algorithms. Initial testing of the ACA with data obtained from USACERL, Hill Air Force Base (Utah), and Ft. Eustis (Virginia) is currently being evaluated. Various sample case studies have been performed to illustrate the usefulness of the ACA. (7) A plan to use the ACA at Radford Army Ammunition Plant is currently underway.

To date, the Ft. Eustis study has involved modeling the emissions at Ft. Eustis to verify the existing Ft. Eustis emissions inventory. The ACA identified approximately 20 issues concerning the Ft. Eustis Emissions Inventory. (8)

The ACA was used to complete an analysis of a paint spray booth at Hill AFB. The results of this study were used to address the significance of the types of results that the ACA provides; the relevance of the specific results presented for Hill AFB by the ACA; and areas for improving the ACA. The study involved modeling four scenarios with the ACA to find options for controlling emissions from the spray paint operation and providing cost estimates. Differences were found between an independent study for Hill AFB and the results generated by the ACA. (9, 10) These differences served to highlight a few issues that a base level EC might want to resolve prior to acting on conclusions drawn in the independent study.

7.0 THE NEEDS OF THE ONTARIO MINISTRY OF ENVIRONMENT AND ENERGY

While the MOEE has several roles which differ in their requirements from that of an environmental coordinator at a source facility, there are significant areas of overlap. As the lead contact with industry, from time to time staff in the district and area offices of the MOEE need to be able to give advice to source owners as to how to meet requests for information or legislated requirements. Local staff also need resources to allow them to evaluate alternatives available for sources with emissions problems before embarking on abatement programs. There is a continuing need to deliver timely processing of approvals applications while ensuring that regulatory and policy requirements are being met based on technically sound criteria. As resource needs remain under constant scrutiny, resolution of these needs can safely be assumed to require innovative approaches which do not increase staffing.

Generally, the staff of MOEE local offices have limited information on hand relating to air emissions. Often district offices have detailed information only on the more significant local sources, and limited access to a broader range of literature sources. Requests for more detailed information have often been referred to staff at a resource branch where detailed information is more available. Local staff might be obligated to place all or part of the abatement planning process on hold until resource staff can generate their response. With the current need to empower field staff and eliminate bottlenecks, some means to transfer greater information to field staff while retaining a consistent overall approach with low cost would be very beneficial.

While many aspects of the review have been streamlined in the approvals process by the use of computer-based calculations, there remains a significant potential to speed technical review by better integrating the ability to search for emissions data with the calculations of control technology performance and the performance of dispersion calculations. While this gain would be modest, in the current environment where resources are constrained and turnaround times remain under pressure any possible time savings are of interest. An even greater savings in time might be possible if applicants were to use such a package and submit the results file along with their application for approval. This would provide assurance to the applicant by reducing the possibility of unanticipated issues developing during the review. It would also simplify the review by eliminating the need to re-key data into the input file.

8.0 HOW THE ACA CAN MEET THE NEEDS OF THE MINISTRY OF ENVIRONMENT AND ENERGY

The current focus of the ACA is its utility to the source owner in assessing alternative approaches to achieving regulatory compliance. Clearly, adoption of the ACA as a tool by Ontario industries could be of benefit to both industry and the MOEE. Having the ability to identify solutions to problem situations, estimate costs and evaluate the likely effectiveness in achieving regulated limits allows staff of both industry and the Ministry to negotiate compliance strategies based on reasonable data. The use of the ACA by Ministry district staff would allow decision-making based on sound technical considerations to be taken with less delay. By incorporating Ontario-specific regulation modules, much like those developed for the U.S. federal regulations, both industry and Ministry staff could evaluate the compliance status of a facility and either (a) the options available to reach compliance or (b) determine what additional information is needed to determine compliance status. These evaluations have the advantage of being done using a consistent methodology (providing a level playing field) while still allowing for considerable customization to incorporate site-specific data.

Use of the ACA in the approvals process could assist in the aim of streamlining approvals reviews by reducing the need to physically re-enter data required for different aspects of the review, while integrating into one package most of the calculations which typically need to be performed. If Ontario-specific regulation modules were developed for use with the ACA, simpler applications might be reviewed almost automatically. If the applicant were to use the ACA and submit the data files developed as part of the application preparation process, the degree of uncertainty over whether approval would be forthcoming would be greatly reduced. Depending upon the degree to which the regulation modules are able to reflect fine details of Ministry requirements, the applicant could even be aware of the type of conditions might be placed on the approval before applying.

The adaptability of the ACA package through programming of new modules using the EXL language is of particular interest. As it is currently written the ACA package has several applications for potential internal Ministry use, and it should be of interest to industrial source owners as well. However, that existing utility can be extended further through add-on modules customized to address applications which the ACA does not currently address (e.g., Ontario regulations or calculations to be performed for quality assurance purposes within the MOEE). This aspect may be of interest to industrial users implementing ISO 14000 and wishing to provide an audit trail demonstrating compliance corporately with the proposed Standardized Approvals Regulations (SARs). Specific modules addressing each SAR could be written for use in demonstrating due diligence and compliance with company policy under an

ISO 14000 environmental management policy/system. These modules need not be written by the Ministry.

To the Ministry staff who have examined the package, the ACA seems best applied as a tool for knowledgeable practitioners rather than a replacement for them. There remain areas of source characterization and control technology evaluation which are too poorly defined to be incorporated into the program. However, its application to the task of building facility-specific source inventories and devising cost-effective control strategies should be of particular use to abatement staff and to industry. With extensions to permit better integration with dispersion models, it would be of even greater application. Additional extensions to capture the functionality of Ontario's regulations and policies, similar to those incorporated for the U.S. federal regulations, would likely be of even greater utility to industrial users.

Since the ACA is being developed for distribution as freeware at this time, it may serve as a suitable framework for private sector developers in the environmental software field to build on. Depending upon the circumstances, this could occur under contract to the Ministry, to a user industry or industrial association, or as a specialized retail marketing venture. No plans have been made regarding future development of modules; the Ministry sees a possible role for all three approaches.

Ministry staff intend to work with Argonne National Laboratory as part of the user group providing feedback on the existing version of the ACA. This should assist the program developers in addressing the needs and viewpoint of a typical regulatory user, and ensure the ACA is as useful to the Ministry as possible "off the shelf." Ministry staff encourage potential industrial users based in Ontario to follow the same approach to ensure that their issues are also addressed. As with most software, exposure to the capabilities of the ACA is likely to lead to further suggestions for improvement and extension of the software.

9.0 CONCLUSIONS

The functionality of the ACA satisfies a need realized at both the DoD and MOEE. It requires minimal data input (for basic analysis), uses data from a wide variety of sources, and solves real world problems. The ACA is extendible (by the developers, end-users, EPA, and industry) and can handle the complex data and algorithms for air pollution problems. The ACA assists end-users with the development of air compliance strategies. The MOEE has a continuing need to deliver timely processing of approval applications while ensuring that regulatory and policy requirements are met. The ACA provides an innovative approach to meet the MOEE's needs.

The latest beta test version and user's manual for the ACA can be downloaded from the EPA's Control Technology Center (CTC) bulletin board, or from the ACA Development Group's World Wide Web site (http://quattro.me.uiuc.edu/~acad). It is anticipated that a pre-release version of the ACA will be available by 01 July, 1997.

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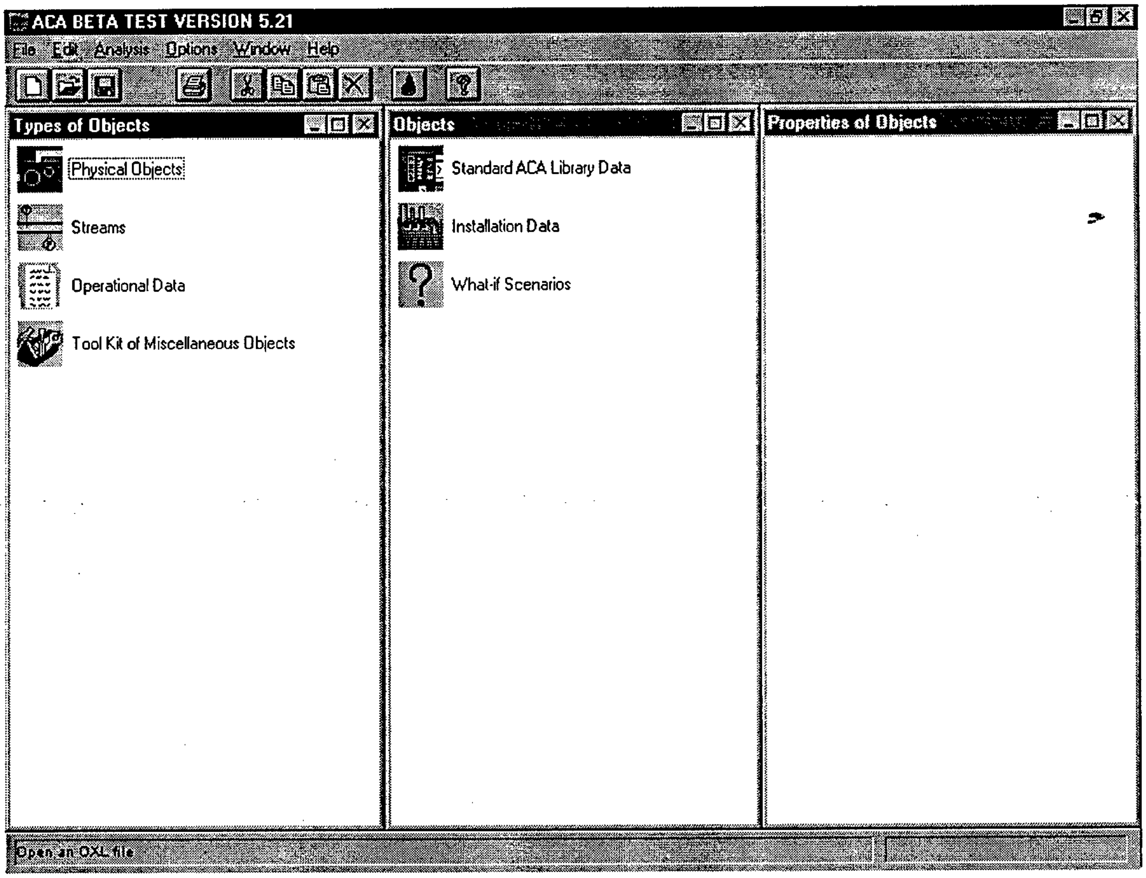

Figure 1. Screen capture illustrating the ACA at start-up.

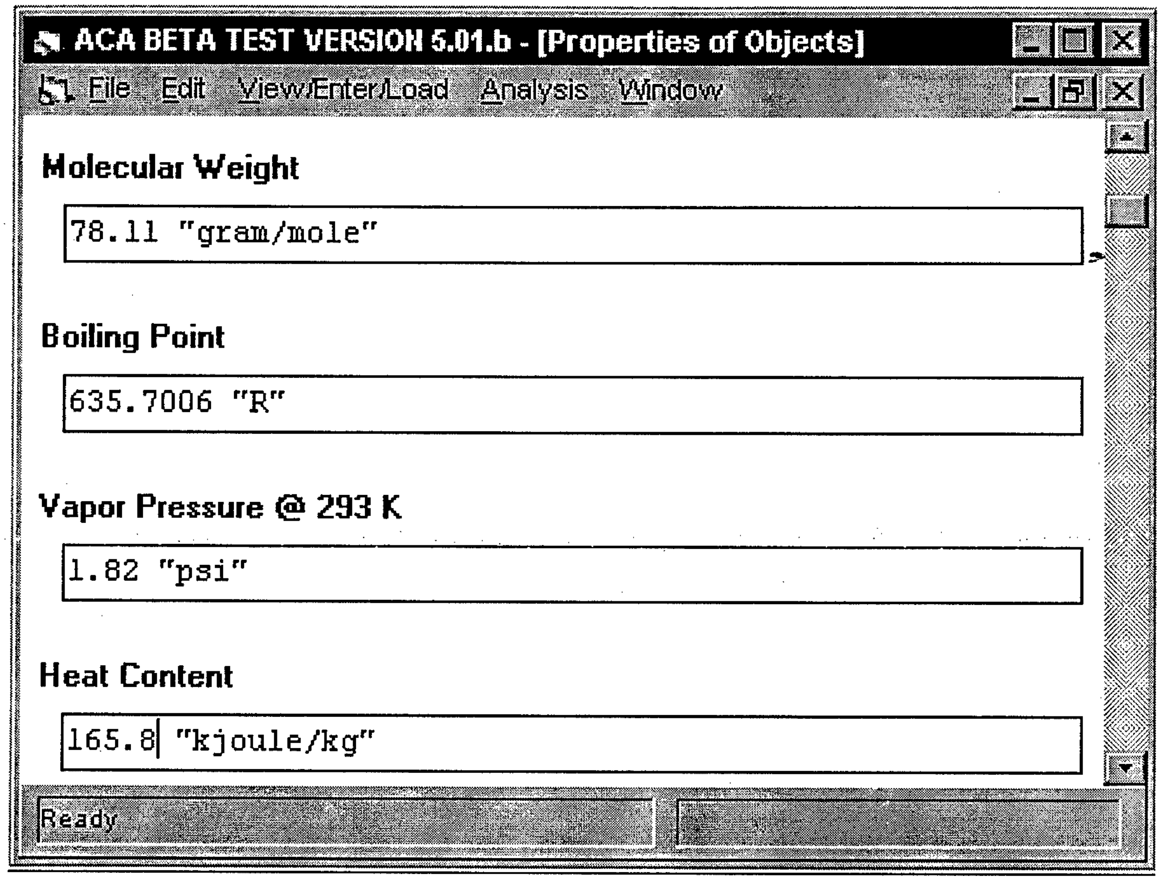

Figure 2. Screen capture illustrating different units available in the ACA.